Decision Making and Track Control of Autonomous Vehicles

Our Team and Contribution

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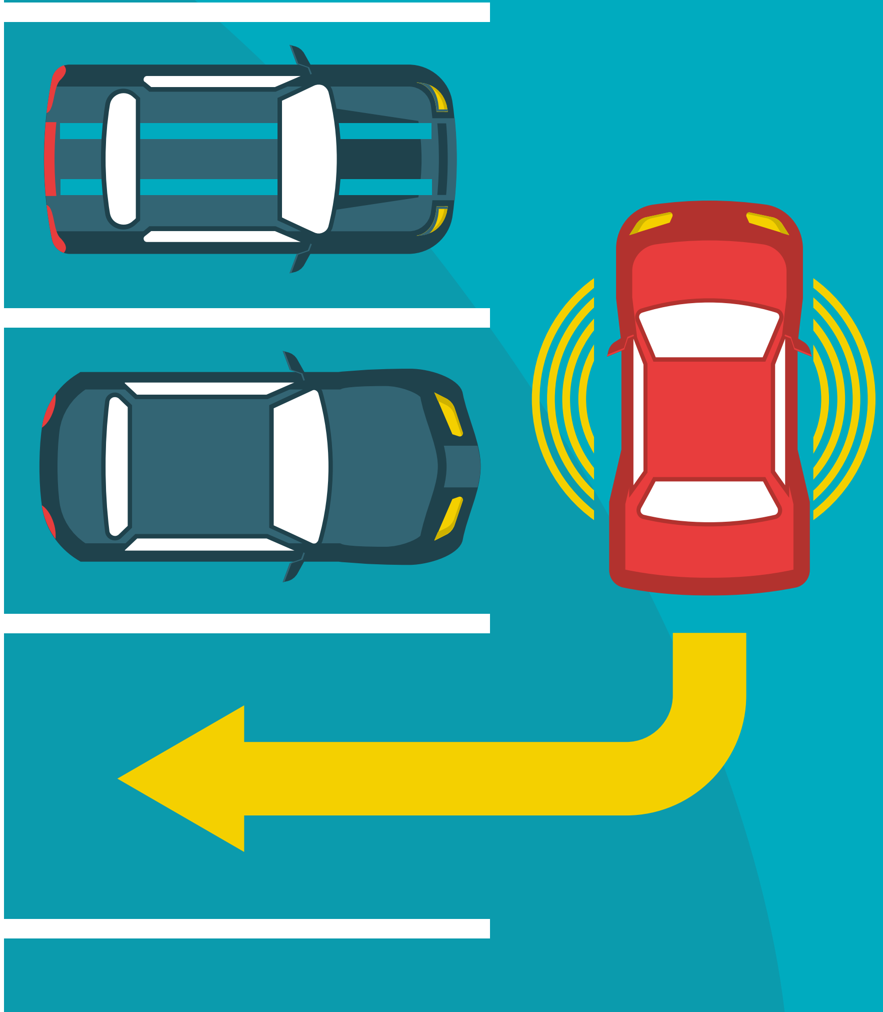


REVIEW 0

PROBLEM STATEMENT

Design and develop a self-driving car system that can safely and efficiently navigate through various traffic scenarios, including intersections, lane changes, and pedestrian crossings, while obeying traffic laws and avoiding collisions. The ultimate goal of the project is to create a self-driving car that can reduce accidents and make transportation safer and more efficient for everyone.

Abstract

Self-driving cars have revolutionized the automotive industry by eliminating the need for human drivers. These vehicles are designed to operate autonomously, using advanced technologies such as neural networks to navigate the roadways and avoid obstacles. A neural network is a type of machine learning algorithm that is modelled after the structure of the human brain. It consists of interconnected nodes that work together to process information and make decisions. By analyzing data from various sensors, including cameras, lidar, and radar, a self-driving car can create a 360-degree view of its surroundings. Neural networks play a key role in this process, helping to form a logical network that enables the car to make decisions based on the information it collects. To visualize this process, one can imagine multiple rays emanating from the car and scanning the environment. Based on the data received, the neural network is able to determine where obstacles are located and make appropriate adjustments to the car's speed and trajectory. To ensure that the self-driving car feels as realistic as possible, realistic car physics are also implemented. This helps to create an authentic driving experience, even though the car is being operated by a machine rather than a human. One of the advantages of using neural networks in self-driving cars is their ability to learn and adapt over time. As the vehicle collects more data and experiences different scenarios on the road, the neural network can refine its algorithms and improve its decision- making capabilities. Overall, neural networks are a key technology powering the development of self-driving cars.

INTRODUCTION

Self-driving cars have been a popular topic in the field of autonomous vehicles for many years now. These vehicles are designed to operate autonomously, without any human input, using advanced technologies like artificial intelligence (AI) and neural networks to navigate the roadways and avoid obstacles. A neural network is a type of machine learning algorithm that is modeled after the structure of the human brain. It consists of interconnected nodes that work together to process information and make decisions. In self-driving cars, neural networks are used to interpret data from various sensors, such as cameras, lidar, and radar, in order to understand the environment around the vehicle. The neural network in a self-driving car is trained on a vast amount of data, including images, videos, and other sensor data, to identify and classify objects in the vehicle's surroundings. This includes identifying objects like other cars, pedestrians, and traffic signs, as well as understanding the road layout and detecting potential hazards. The development of self-driving cars is driven by the desire to make driving safer and more convenient. With the ability to operate autonomously, these vehicles have the potential to reduce accidents caused by human error, as well as increase the efficiency of travel by reducing congestion and optimizing routes.

Implementation of Algorithm in:

1. Car.js
2. Control.js
3. Main.js
4. Network.js
5. Road.js
6. Sensor.js
7. Utlis.js
8. Visualizer.js

Societal Benefits

1

Improved road safety

Self-driving cars can eliminate human error, which is a major cause of road accidents. As a result, self-driving cars could significantly reduce the number of accidents on the road, which would lead to fewer injuries, deaths, and property damage.

2

Increased mobility

Self-driving cars could help to increase mobility for people who are unable to drive, such as the elderly, disabled, or people who cannot afford a car. This would enable people to travel more easily and access jobs, education, and healthcare services.

3

Reduced traffic congestion

Self-driving cars can help reduce traffic congestion by optimizing traffic flow and reducing the number of accidents on the road. This would help to reduce travel times and improve the overall efficiency of the transportation system.

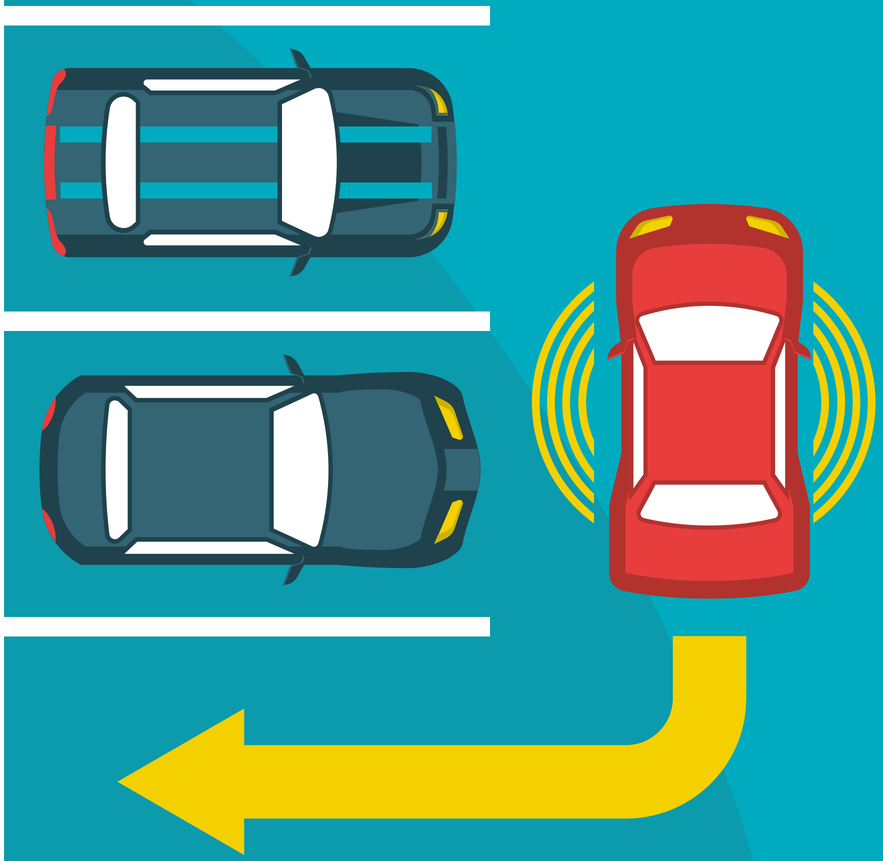
Societal Benefits

4 Lower emissions

Self-driving cars can be programmed to drive in a more fuel-efficient manner, which would help to reduce greenhouse gas emissions and improve air quality.

5 Improved productivity

Self-driving cars can enable people to work, study, or relax while commuting, which would increase productivity and reduce stress.



REVIEW 1

Literature Survey

End-to-End Learning for Self Driving Cars

2016

A Survey of Autonomous Vehicle Technologies, Applications, and Social Impacts

2018

2018

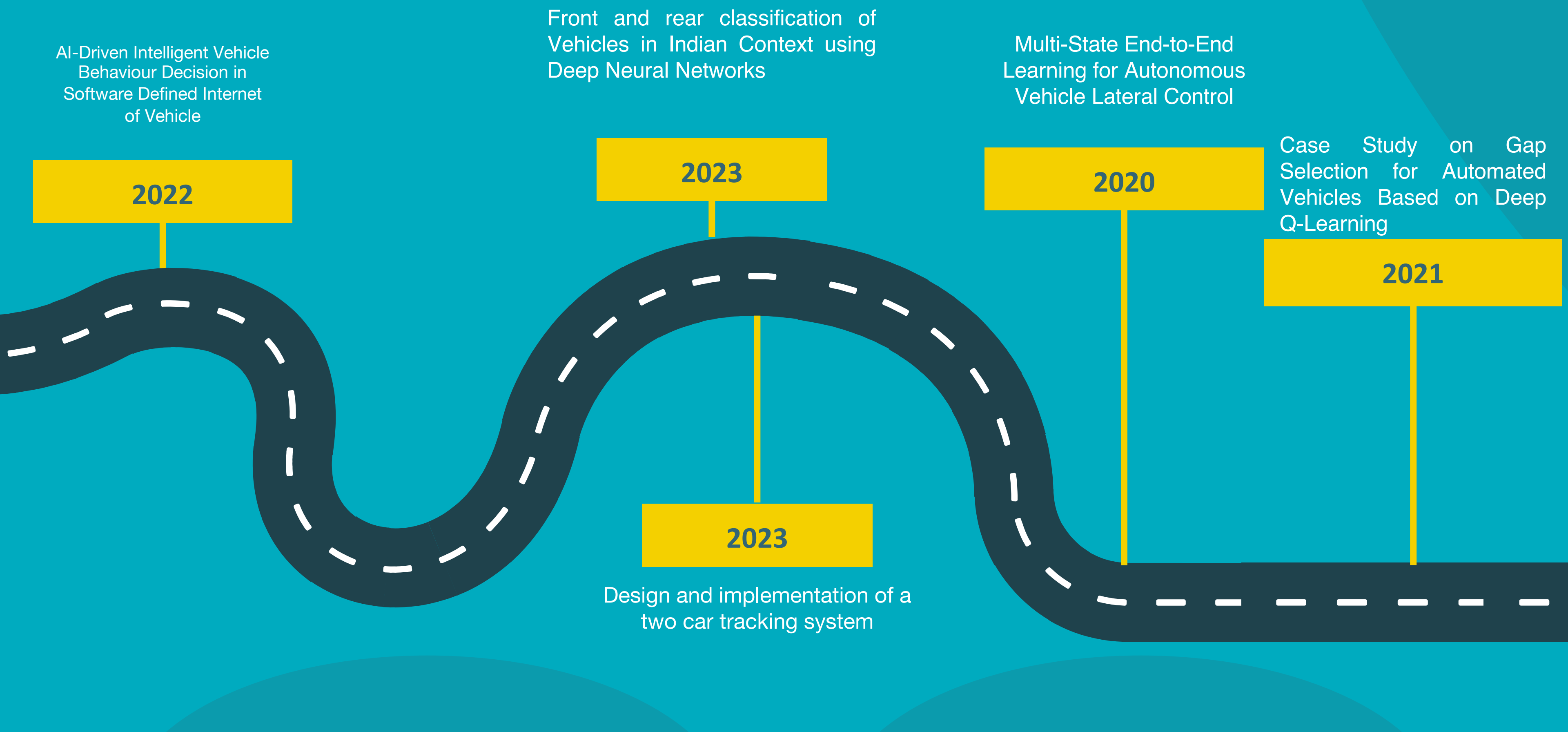
Probabilistic Collision Detection for Autonomous Driving using Gaussian Process Dynamics and a Dynamic Occupancy Grid

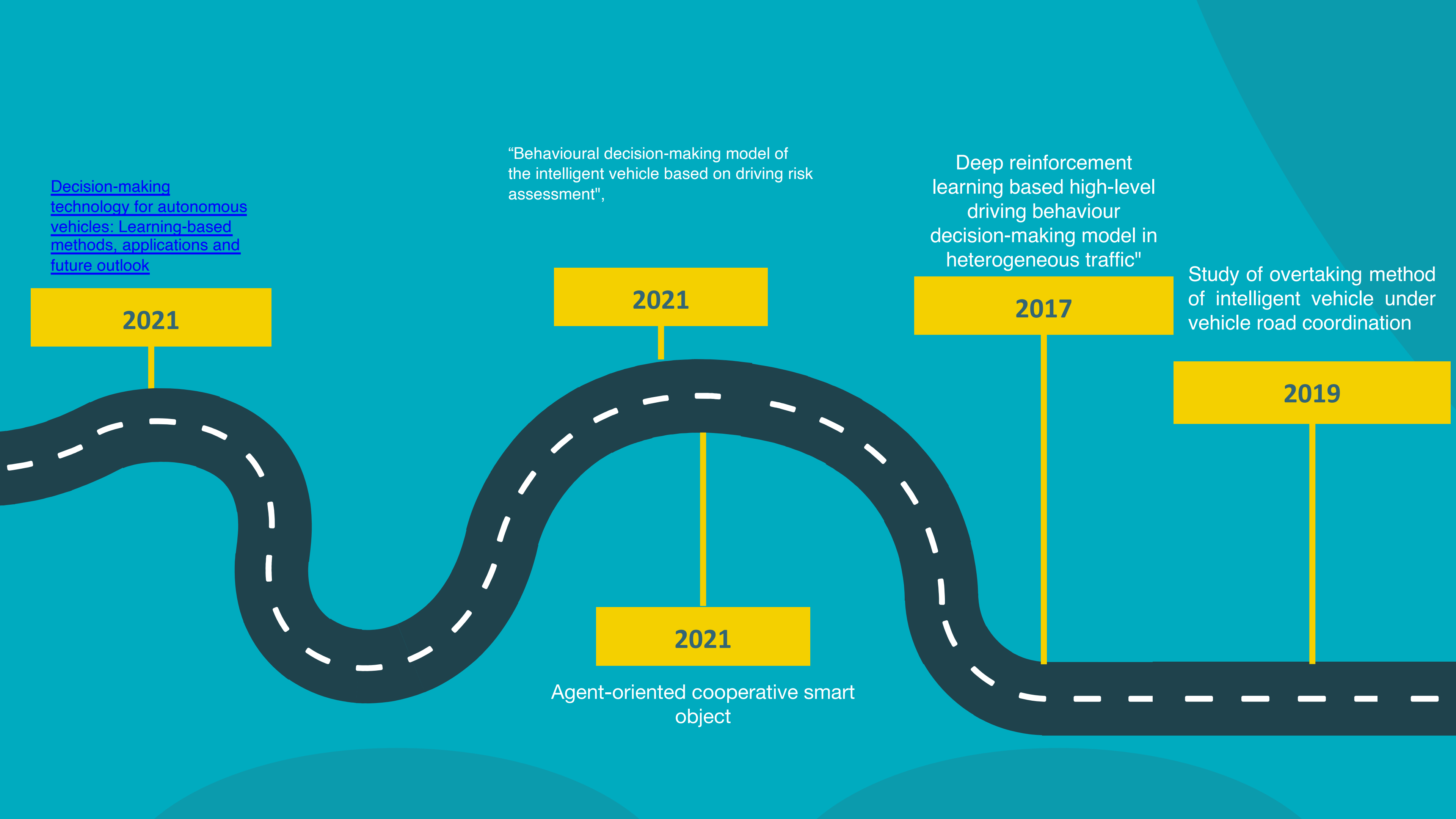
Designing Safe and Explainable Autonomous Vehicles

2020

Perception for Autonomous Driving: A Survey

2021


AI-Driven Intelligent Vehicle Behaviour Decision in Software Defined Internet of Vehicle
2022
Front and rear classification of Vehicles in Indian Context using Deep Neural Networks
2023
2023
Design and implementation of a two car tracking system
Multi-State End-to-End Learning for Autonomous Vehicle Lateral Control
2020
Case Study on Gap Selection for Automated Vehicles Based on Deep Q-Learning
2021


Decision-making technology for autonomous vehicles: Learning-based methods, applications and future outlook
2021
"Behavioural decision-making model of the intelligent vehicle based on driving risk assessment",
2021
2021
Agent-oriented cooperative smart object
Deep reinforcement learning based high-level driving behaviour decision-making model in heterogeneous traffic"
2017
Study of overtaking method of intelligent vehicle under vehicle road coordination
2019

Paper Name	Author and Year	Inference
End-to-End Learning for Self Driving Cars	Mariusz Bojarski (2016)	This paper proposes an end-to-end deep learning approach for self-driving cars that directly maps raw sensor inputs to steering commands. The authors demonstrate that their model can learn to drive on a wide range of roads and conditions, without the need for explicit feature extraction or sensor fusion.
A Survey of Autonomous Vehicle Technologies, Applications, and Social Impacts	Feng Yu and Joann S. Kowalski (2018)	This paper provides a comprehensive survey of autonomous vehicle technologies, applications, and social impacts, including regulatory, legal, ethical, and economic considerations. The authors analyze the potential benefits and challenges of self-driving cars, as well as their implications for urban planning, transportation policy, and human behavior.
Probabilistic Collision Detection for Autonomous Driving using Gaussian Process Dynamics and a Dynamic Occupancy Grid	Alexander Katrutsa (2018)	This paper proposes a probabilistic collision detection approach for self-driving cars that combines Gaussian process dynamics with a dynamic occupancy grid. The authors demonstrate that their method can improve collision avoidance performance compared to traditional occupancy grid-based methods, especially in complex and dynamic environments.
Designing Safe and Explainable Autonomous Vehicles	Tim Miller (2020)	This paper proposes a framework for designing safe and explainable autonomous vehicles that integrates formal verification, uncertainty quantification, and explainability methods. The authors demonstrate that their approach can improve the safety and reliability of self-driving cars, while also increasing user trust and transparency.
Perception for Autonomous Driving: A Survey	Ming Liang (2021)	This paper provides a comprehensive survey of perception technologies for autonomous driving, including sensor fusion, object detection and tracking, and semantic segmentation. The authors analyze the advantages and limitations of different perception methods, as well as their potential applications in self- driving cars.

Paper Name	Author and Year	Inference
AI-Driven Intelligent Vehicle Behaviour Decision in Software Defined Internet of Vehicle	Jiayi Liu , Kai Lin , Giancarlo Fortino (2022)	This paper says decision-making systems receiving less attention. In order to improve the accuracy of intelligent vehicle behaviour decision making and ensure the active safety of path planning, this paper firstly establishes an edge intelligence based software-defined Internet of Vehicles (ESIOV) architecture.
Front and rear classification of Vehicles in Indian Context using Deep Neural Networks	Manas Kumar Rath , Prasanta Kumar Swain (2023)	In this paper to detect whether a vehicle under consideration is moving in the correct lane , we find various hinderances such as faded markings, shadows ,different lighting conditions, rural roads etc . Hence, one of the important intermediary task is to defect the view of other vehicles that come in the vicinity of vehicle .
Design and implementation of a two car tracking system	Yuxiang Shang , Qiyao Yang , Yikai Ma , Jiaxin Gao , Yuxi Zhu , Mengyao Yuan(2023)	In this paper an ultrasonic module is added to the following car to detect the distance between two cars .
Multi-State End-to-End Learning for Autonomous Vehicle Lateral Control	Simone Mentasti , Mattia Bersani , Matteo Mateucci ,Federico Cheli (2020)	In this paper is an alternative end-to-end approach to the problem. Images acquired by a camera mounted on the vehicle are processed by two convolutional neural networks to directly retrieve the steering command.
Case Study on Gap Selection for Automated Vehicles Based on Deep Q-Learning	Matthias Nichting , Thomas Lobig , Frank Köster (2021)	This paper discusses a setup for learning decisions by applying reinforcement learning. It further exemplifies this with a purposefully not overly complex use case, the merging onto a road before the end of the ego vehicle's lane.

Paper Name	Author and Year	Inference
Decision-making technology for autonomous vehicles: Learning-based methods, applications and future outlook	Q liu , X li , S yuan (2021)	This article proposes a brief review on learning-based decision-making technology for autonomous vehicles since it is significant for safer and efficient performance of autonomous vehicles.
“Behavioural decision-making model of the intelligent vehicle based on driving risk assessment",	X Zao , Q .Xu (2021)	This paper presents a new behavioural decision-making model to achieve both safety and high efficiency and also to reduce the adverse effect of autonomous vehicles on the other road users while driving .
Agent-oriented cooperative smart object	G. Fortino, W. Russo, C. Savaglio, W. Shen and M. Zhou(2017)	In this paper an ultrasonic module is added to the following car to detect the distance between two cars .
Deep reinforcement learning based high-level driving behaviour decision-making model in heterogeneous traffic"	L Chai ,Z Bai(2019)	In this paper is an alternative end-to-end approach to the problem. Images acquired by a camera mounted on the vehicle are processed by two convolutional neural networks to directly retrieve the steering command.
Study of overtaking method of intelligent vehicle under vehicle road coordination	Y wang , K yin (2021)	This paper discusses a setup for learning decisions by applying reinforcement learning. It further exemplifies this with a purposefully not overly complex use case, the merging onto a road before the end of the ego vehicle's lane.

Limitations

Limited Environmental Perception

Difficulty in handling complex situations

Limited understanding of social cues

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Cybersecurity risks

Legal and regulatory challenges

Limitations

Limited Environmental Perception

While self-driving cars are designed to handle a variety of driving situations, they can still struggle with complex scenarios such as merging onto a crowded highway, navigating a construction zone, or reacting to unexpected events like a pedestrian suddenly crossing the road.

Difficulty in handling complex situations

Self-driving cars rely on sensors such as cameras, radar, and lidar to perceive their surroundings. However, these sensors can be limited by poor visibility due to weather conditions such as heavy rain, snow, or fog. Additionally, they may not be able to detect certain objects such as potholes, road debris, or animals.

Limited understanding of social cues

Human drivers often rely on non-verbal communication and social cues to interact with other drivers and pedestrians. Self-driving cars have limited ability to understand these social cues, which can lead to unpredictable behaviour and accidents.

Cybersecurity risks

Self-driving cars rely heavily on software and connectivity, which can make them vulnerable to cyber-attacks. Hackers could potentially take control of a self-driving car's systems, leading to dangerous or even deadly situations.

Legal and regulatory challenges

Self-driving cars are subject to a complex web of laws and regulations that vary by state and country. Current regulations may not fully address the unique challenges presented by self-driving cars, which can make it difficult for manufacturers to develop and deploy these vehicles at scale.

Objectives

SAFETY

01

Self-driving cars can optimise their routes to avoid traffic and choose the fastest, most efficient path to their destination. This can help reduce travel times and congestion on the roads.

02

EFFICIENCY

The primary objective of a self-driving car is to improve safety on the roads by reducing accidents caused by human error. Self-driving cars can constantly monitor their surroundings and make split-second decisions to avoid collisions, even in complex traffic situations.

03

ACCESSIBILITY

Self-driving cars can make transportation more accessible to people who are unable to drive due to age, disability, or other factors. This can help improve mobility for a wide range of individuals.

ENVIRONMENTAL IMPACT

04

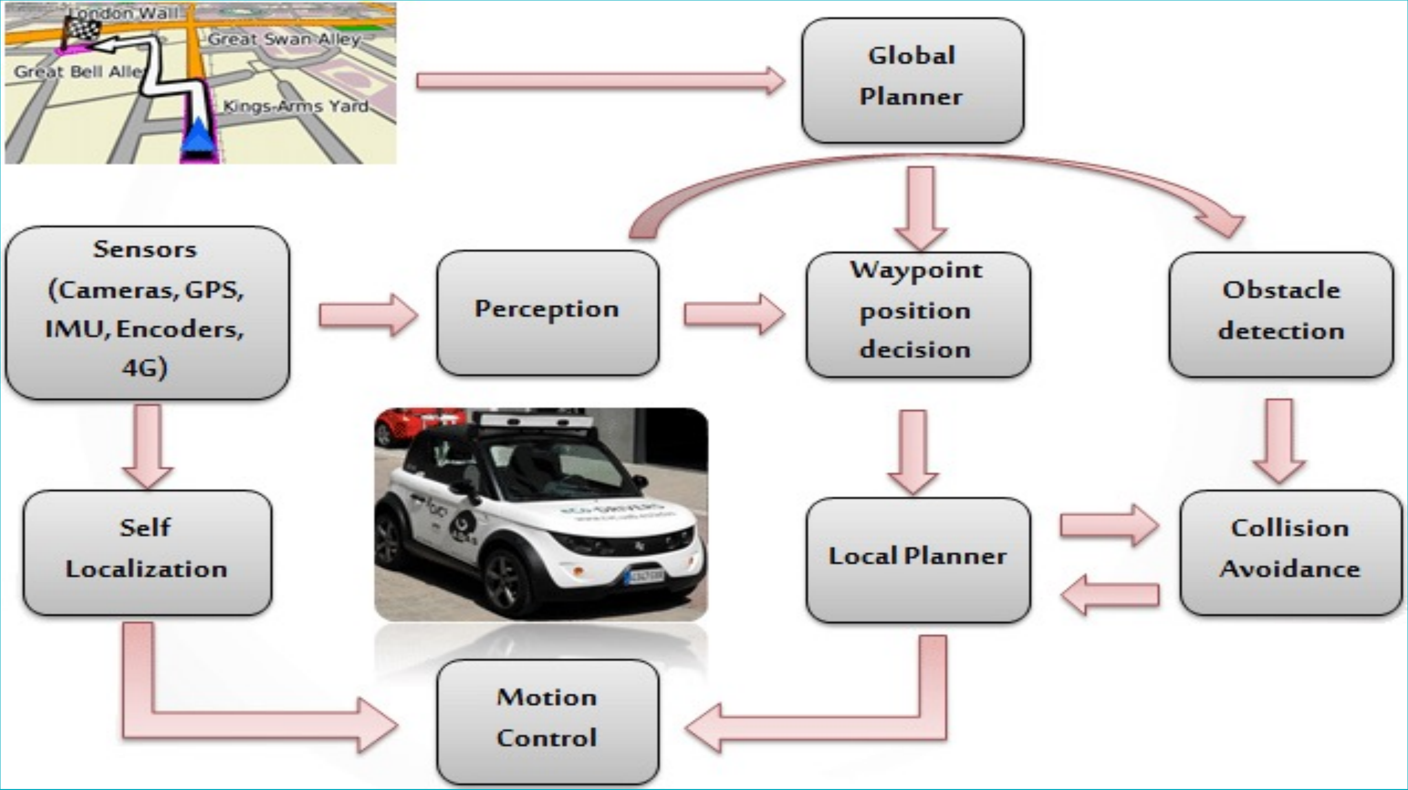
Self-driving cars can be programmed to drive in a more eco-friendly manner, such as by accelerating and braking more smoothly and avoiding idling.

05

COST SAVINGS

Self-driving cars can potentially reduce the cost of transportation by eliminating the need for a human driver, reducing fuel consumption, and improving the lifespan of the vehicle.

ARCHITECTURE DAIGRAM



Modules

Sensors

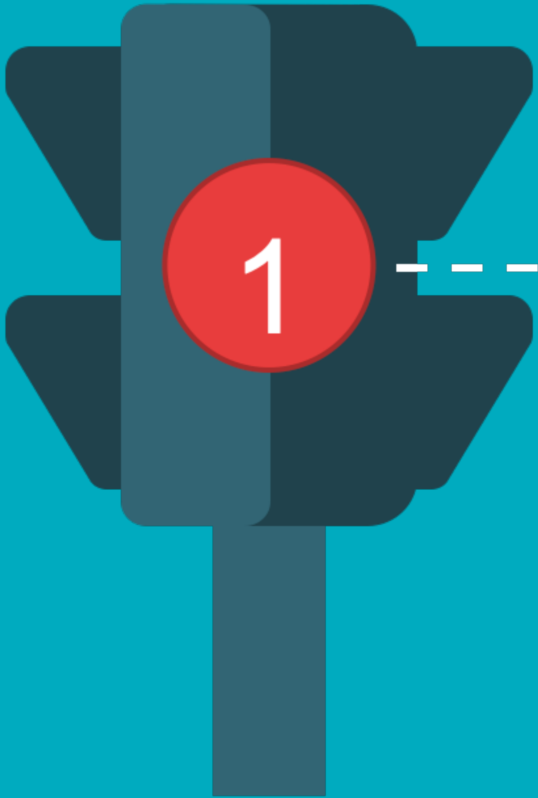
Self-driving cars are equipped with a variety of sensors that allow them to perceive the environment around them. These include cameras, lidar sensors, radar sensors, and ultrasonic sensors.

Perception module

The perception module processes the data from the sensors to build a detailed 3D map of the car's surroundings. This module uses computer vision and machine learning algorithms to identify objects such as other cars, pedestrians, road signs, and traffic signals.

Control module

The control module is responsible for controlling the car's movements. It receives instructions from the planning and decision-making module and uses actuators such as the steering, throttle, and brakes to execute those instructions.



MODULE 1 : sensor.js

JS sensor.js > Sensor > update

```javascript
class Sensor{
    constructor(car){
        this.car=car;
        this.rayCount=5;
        this.rayLength=150;
        this.raySpread=Math.PI/2;

        this.rays=[];
        this.readings=[];
    }

    update(roadBorders,traffic){
        this.#castRays();
        this.readings=[];
        for(let i=0;i<this.rays.length;i++){
            this.readings.push(
                this.#getReading(
                    this.rays[i],
                    roadBorders,
                    traffic
                )
            );
        }
    }

    #getReading(ray,roadBorders,traffic){
        let touches=[];

        for(let i=0;i<roadBorders.length;i++){
            const touch=getIntersection(
                ray[0],
                ray[1],
                roadBorders[i][0],
                roadBorders[i][1]
            );
            if(touch){
                touches.push(touch);
            }
        }
```

sensor.js

The "Sensor" class is part of a larger system that simulates a car driving in an environment. The class represents a sensor that can detect objects and obstacles in the environment using rays that are cast in a spread around the car. The constructor sets default values for the number of rays, their length, and spread, as well as an empty array for the readings. The update method updates the sensor readings by casting rays and checking for intersections with the road borders and traffic objects in the environment. The private getReading method calculates the closest intersection of the rays with the environment and returns it as the sensor reading. The private castRays method generates the rays to be cast based on the sensor's settings and the car's position and angle. The draw method visualizes the rays and readings on a canvas by drawing lines between the ray origin and the intersection points with the environment. Overall, the "Sensor" class provides a basic simulation of a sensor used in autonomous driving systems.

The "Sensor" class is a JavaScript code that defines a sensor object with properties for the car it's attached to, the number of rays it should cast, the length and spread of the rays. It has methods to update the sensor's readings based on the road borders and traffic present in the environment, and to draw the rays and readings on a canvas. The code uses private methods to cast rays and get the intersection of the rays with the environment. The class uses concepts like arrays, loops, and conditional statements to implement its functionalities. It is beaming out of rays in front of cars, these rays are connected to the input layer of a neural networks which helps in avoiding collisions .

References :

1. https://ieeexplore.ieee.org/document/8852322/references#references

2. https://www.researchgate.net/publication/282667130_A_Review_and_Analysis_of_Literature_on_Autonomous_Driving_E-Journal_Making-of_Innovation

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4. https://ieeexplore.ieee.org/document/9307428?denied=

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